The insect fauna of the lake shore presents material for a study in itself, on which nothing has been published save the material on Diptera by Aldrich, already cited. At the University of Utah I left the beginning of a collection of insects taken in or on the waters of the lake, and I recall that a small Corisid was several times seen and some specimens of it taken swimming immersed in the brine near shore. The species appeared to be the same as one common in fresh and slightly salt and sulphur impregnated waters in the Salt Lake valley.

Probably correlated with the abundance of *Ephydra* adults as food, may be mentioned a "plague of spiders" with which the resort (Saltair) was troubled during one bathing season, about 1910. Several cases of persons being bitten by spiders were reported in one of the Salt Lake papers, though I can not vouch for their authenticity. Certain it is that spiders of more than one species were unusually numerous about the pavilion, as I personally observed, and I learned later that the employees went about with brooms every morning before the hour for opening and destroyed as many as possible. The forest of piles and underpinning beneath the structure, however, was an inexhaustible reservoir from which the supply was constantly renewed. After the close of the season, no other remedy having been found, some employees were kept busy for weeks in boats beneath the huge structure collecting and destroying the egg cocoons, and the next season there was no serious trouble. Many bushels were thus collected. The second autumn this task was again taken up, and since that time no further plague of spiders has appeared, but whether autumn cocoon collecting is still kept up I do not know. I have no doubt that the seemingly sudden appearance of the great numbers of spiders was in reality but the time when, owing to the availability of a great food supply and plenty of space for spreading webs, they reached a high point in numbers, the culmination of years of slow increase.

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ON THE FLORA OF GREAT SALT LAKE

VERY little investigation has been made of the plant life of Great Salt Lake, either of a scientific nature or otherwise. So far as the author of this paper knows, but one attempt has been made in the past so scientifically classify the flora of the lake, and

that attempt was interrupted before it had reached a successful conclusion, so that no publication of the work was made.

Brief mention of what literature we have on this subject seems not to be out of place here.

Professor Farlow (1879)[1] published a description of a blue-green alga, *Polycystis packardii.*

Dr. A. Rothpletz (1892)[2] makes mention of the presence of certain genera of blue-green algæ, connecting them with the formation of peculiar ooliths on shore. Dr. Rothpletz did his work as a geologist, from a geological point of view. He made no systematic study of the lake from a botanical standpoint. The genera of algæ he mentions—*Gleothece* and *Gleocystis*—we have been unable to find in the part of the lake studied, and it might be said, too, that the connection between these and the ooliths has not been generally accepted, even by geologists.

H. F. Moore (1899)[3], in reporting on the feasibility of introducing useful marine animals into the waters of the lake, makes mention, briefly, of the presence of diatoms. As diatoms constitute the chief food of the oyster, their presence was of considerable importance in the investigation, and especially since they are found in greatest abundance at the mouths of rivers where the density of the water is more favorable for the development of the oyster.

Talmage (1900)[4] speaks of the presence of at least three species of algæ—not naming them—and, besides these, he calls attention to the presence of diatoms beds off from shore, as well as living diatoms in the lake.

Miss Tilden published in her distribution entitled "American Algæ," several species from Great Salt Lake. This distribution has not been available, therefore, more definite mention of it can not be made. They are as follows:

Aphanothece utahensis, no. 297,
Polycystis packardii, no. 298,
Dichothrix utahensis, no. 288,
Enteromorpha marginata, no. 266,
Enteromorpha tubulosa, no. 262,
Chara contraria, no. 255.

No other proof of the presence of abundant plant life in the

[1] This paper was not available.

[2] Rothpletz, A., *Bot. Centr.*, p. 35.

[3] Moore, H. F., "The Feasibility of Introducing Useful Marine Animals into the Waters of Great Salt Lake."

lake is needed than the presence of a fauna, abundant in individuals, if not in species. And no further demonstration of the presence of this fauna is required than for one to visit the lake and see, with his own eyes, the water literally teeming with animal life.

The presence of plants is not so evident to the casual observer, although, at certain times of the year, clumps of greenish material, which must at least suggest a vegetable growth, are very plentiful. Areas of a green scum on the surface of the water in more or less protected places also give evidence, directly, of the presence of plants.

The original purpose of this paper was to determine, if possible, the effect as to size of cells and rapidity of growth of different densities of Great Salt Lake water on a species of *Chlamydomonas* which is found there. The problem, then, was to have been purely a physiological one. During the course of investigations along this line, however, other interesting things presented themselves, and a deviation was made from the first plan, so that finally observations were extended to include every species of plant found in the part of the lake investigated.

The observations made covered a small portion of the southern end of the lake at what is known as Saltair Beach. This place is easily accessible, and is at such a distance from any stream entering the lake, that the density of the water there is not affected to any degree.

The following plants are found regularly in the water at that place:

A green alga, *Chlamydomonas* sp., which has been examined by Dr. N. L. Gardner. Dr. Gardner believes it to be a new species—he has not yet published a decription—near to *Chlamydomonas glœocystiformis* Dill, and *Chlamydomonas apiocystiformis artari*. It has a rich green color, and occurs, during the warmer weather, on the surface of the water in many more protected places. It is found in less numbers in whatever decaying plant or animal material may be present. The indications are that this is one of the means the plant has of surviving the winter; since such material brought into the laboratory in the very coldest weather has later developed a rich green growth of the alga.

A blue-green alga, determination of which has been made by Professor W. A. Setchell. He says that it certainly is an *Aphanotheca*, and is undoubtedly the same plant as the one named *Polycystis packardii* by Farlow, and probably also the

same as the one distributed by Miss Tilden from the Great Salt Lake and named by her *Aphanothece utahensis*. On the authority of Professor Setchell, we shall designate it *Aphanothece packardii*.

The plant occurs in small masses, irregular in size, floating in the water and piled up by the waves on shore. These masses show a gradation in color from a deep blue-green, to light brown, and some were colorless; this depending, no doubt, on the conditions of the plants in the individual clumps, and not, as has been suggested,[4] on a variety of species in the clumps. Microscopic examination of this material shows the individual plants in the mature condition, and also in various stages of division by fission. Great numbers of the cells are held together by their gelatinous secretions. The individual plants average about two micra in diameter.

Microscopic examination of the lake water reveals at least two species of diatoms. They probably belong to the genera *Navicula* and *Cymbella*. These plants do not occur in sufficient numbers, in the denser water about Saltair, to be seen with the naked eye.

The fact that putrefaction and decay are taking place in the water, especially near to shore, where organic material is abundant, shows conclusively that bacteria are present.

Here it may be well to suggest that at least some of the plants distributed by Miss Tilden as Great Salt Lake plants, in all probability came from the fresher waters at and near the mouths of rivers, or in the bays formed by the rivers at their place of entrance into the lake. As the present observations were confined to the denser waters, even an indication of the plants referred to—with the one exception noted—was not found.

For the physiological work, water was transferred from the lake to the laboratory, in sufficient amount to make a number of series of dilutions in glass aquaria. These series included solutions of different density, varying in specific gravity from 1.0115 to 1.222, a saturated solution.

Masses—large in some series, but small in one—of *Aphanothece packardii* were placed in these solutions, and, in every case, enough *Chlamydomonas* was thus introduced to start a more or less flourishing growth.

From time to time, measurements were made of the *Chlamydomonas* present in the solutions, and during the first few

[4] Talmage, J. E., "The Great Salt Lake—Present and Past," p. 76. Salt Lake City.

months indications pointed very strongly to the fact that a reduction in size followed transplanting into less dense solutions.

A table below shows the results obtained with the first series. No. 1 contains the water as obtained from the lake, analysis of a sample of which (1910)[5] gives the following:

Constituents	Grams per Liter	% of Sample Taken	% of Total Solids
Total solids	242.25	20.887	——
Chlorine	126.35	10.91	52.23
SO_4-radical	16.00	1.38	6.65
Magnesium	5.18	0.45	2.14
Calcium	0.98	0.08	0.39
Sodium	85.10	7.25	34.68
Potassium	8.82	0.76	3.66
Total of constituents	242.45	20.83	99.75
Salinity	213.32	18.39	88.09

Solutions 0 and 00 were allowed to become further concentrated by evaporation in the laboratory. Nos. 2 to 8, inclusive, were diluted with distilled water. The first measurements were made some time after the series was started to allow the plants to become accustomed to the new conditions, only, indeed, after multiplication had begun. Blank spaces in the table indicate that no motile zoospores were present at that time in the solution.

SERIES NO. 1 STARTED OCTOBER 8

Measurements

No. of Solution	Density	Dec. 15	Jan. 13	Feb. 14	Mar. 10	Apr. 16	June 15	Average
00	1.222				11.7×6.7		15×10	13.3×8.3
0	1.1825	13×7					15×10	13.7×7.8
1	1.1580	13×7.25	12× .5	13×6.5	12×5.4	12×6	12× 7	12.2×6.1
2	1.1239	13×5			11×5	11×6	10× 5	11.2×5.2
3	1.1088	12×5	11×5		11.2×4.5	11×6	9× 5	10.8×5.1
4	1.0822	12.5×5		12×6.5	11.25×5.5	10×5.5		11.4×5.6
5	1.0613		11×4.3			10×5.5	10× 5	10.3×4.9
6	1.0400	9×4.5		9×5	9×5.5	10×5		9.25×5
7	1.0190		8.5×5		9×4.5	8.5×4.5		8.7×5
8	1.0115				11×6.5	10×5	10× 6	10.3×5.8

This table seems to show a slight diminution in size as we pass from the more dense to the less dense solutions, with the exception of the last and least dense of the solutions. It must be said that it is very difficult in measuring *Chlamydomonas* zoospores

5 McFarlane, Wallace, "The Water of the Great Salt Lake." (Read before the summer meeting (1910) of the Am. Chem. Soc. at San Francisco by Professor W. C. Ebaugh.)

to make definite comparisons as to size. The size of the individual cells even in one solution varies so greatly that one can only obtain an average of the size and then very roughly. The measurements recorded in the table, and all others made, represent the average size of the larger cells in the solutions as far as it was possible under the circumstances to measure them.

The results from the other series did not corroborate definitely the results shown for the first series. Therefore, the only conclusion which can be drawn is, that so far as the present work has shown, variations in density of the water of Great Salt Lake cause no corresponding variations in size of *Chlamydomonas* cells.

In every series but one, decided growth of the *Chlamydomonas* began first in the dilutions about No. 5, and appeared then in order up to No. 1, No. 0, and No. 00, and then down from No. 6 to No. 8. Solutions No. 4, No. 3, and No. 2, as a rule, showed a greater abundance of the zoospores, judging from depth of the green color given to the solutions by them.

The indication is, that water somewhat less dense than that normally present in the lake at its present level is most favorable to development of *Chlamydomonas* sp.

Aphanothece packardii does not grow well in the laboratory cultures. It was interesting to note that they lost their blue-green color and died in the weakest solutions first; this condition following regularly up the series to the most dense solutions. This species gave us no further results. Whether this failure was due to the weak solutions being particularly unfavorable to the alga, or whether it merely indicates that this form is difficult to keep under laboratory conditions, is not certain. The latter seems the more likely conclusion.

The diatoms recovered from the dense waters, on being transferred to the weaker solutions in the laboratory, multiply readily and actually thrive, giving large masses of the characteristic brown growth. In every series, after about a month in the laboratory, solutions No. 1 and No. 2 show a very few live forms which soon die. In No. 3 a few persist; but in No. 4, No. 5, No. 6, and No. 7, they appear abundantly and continue to multiply indefinitely. In No. 8 the live plants are again not very numerous. These observations are in complete harmony with the statements[3] that the diatoms are found in great abundance in the shoaler, fresher waters near to the mouths of the rivers emptying into the lake. They are reported to be especially numerous on

the alluvial fans at the mouths of both the Bear and the Jordan rivers.[3]

The results seem to indicate that the diatoms obtained are true Salt Lake forms, but have become adapted to less severe conditions than prevail in the denser waters. That they are not fresh-water forms which have accidentally found their way into the lake, is suggested by the fact that they do not thrive in the least dense of the solutions of any of the series.

In every series, a cloudiness in the solution appeared as a result of bacterial growth, but the order of appearance in every case was from the least dense solutions up to the most dense. This cloudiness soon disappeared, to reappear at irregular intervals. These facts led to an attempt to determine at least the number of species of bacteria which may be found in the part of the lake studied. So far as we can determine, no attention whatever has been given this phase of the question in the past.

Five distinct organisms, which have adapted themselves to conditions there, were isolated in pure cultures. No detailed study was made of them to determine their species, but enough was done to leave no doubt as to their being at least separate varieties, if one may judge from distinct differences in cultural and morphological characteristics.

Water obtained from the lake under the strictest precautions, was at first plated on phosphorescent, or salt agar, which consists of 40 cc. of normal sodium hydroxide and 25 grams sodium chloride, to 1,000 cc. of plain agar. Later samples of the water were plated on gelatins containing different amounts of the normal $NaOH$, and $NaCl$. Better results were obtained with the salt agar than with the gelatin. Later, plain agar was used with good results.

The number of bacteria per c.c. varies between 200 and 625, counts having been made from a number of samples taken in the coldest weather—water 33° F.—as well as in the warmer weather.

A very interesting fact developed; that of the five micro-organisms isolated, three are decided chromogens, each producing abundant pigment. Of the five, one is a diplococcus, which appears sometimes in tetrads and singly. It forms large white colonies on the media used. The other four are bacilli. The one producing no pigment, forms delicate white colonies on the solid media. Of the chromogens, one produces a lemon-yellow; a second produces a bright orange; and the third produces a violet pigment.

CONCLUSIONS

1. Variations in density of the water of Great Salt Lake, cause no corresponding variations in the size of *Chlamydomonas* sp. cells.

2. The indication is, that water somewhat less dense than that normally present in the lake, at its present level, is most favorable to the development of *Chlamydomonas* sp.

3. The diatoms present in the lake multiply best in water much less dense than the dense water at Saltair.

4. At least four species of algæ are to be found in the part of the lake investigated.

5. At least five varieties—possibly species—of bacteria have adapted themselves to the severe conditions in the lake.

In conclusion, I wish to heartily thank Professor C. T. Vorhies for the suggestions he has given me in the preparation of this paper.

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